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Review

Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 2. Description of Outbreaks by Size, Severity, and Settings

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ABSTRACT

This article is the second in a series of several by members of the Committee on the Control of Foodborne Illness of the International Association of Food Protection, and it continues the analysis of 816 outbreaks where food workers were implicated in the spread of foodborne disease. In this article, we discuss case morbidity and mortality and the settings where the 816 outbreaks occurred. Some of the outbreaks were very large; 11 involved more than 1,000 persons, 4 with more than 3,000 ill. The larger outbreaks tended to be extended over several days with a continuing source of infections, such as at festivals, resorts, and community events, or the contaminated product had been shipped to a large number of customers, e.g., icing on cakes or exported raspberries. There were five outbreaks with more than 100 persons hospitalized, with rates ranging from 9.9 to 100%. However, overall, the hospitalization rate was low (1.4%), and deaths were rare (0.11% of the 80,682 cases). Many of the deaths were associated with high-risk persons (i.e., those who had underlying diseases, malnutrition, or both, as in a refugee camp, or young children), but a few occurred with apparently healthy adults. An analysis of the settings for the food worker–related events showed that most of the outbreaks came from food service facilities (376 outbreaks [46.1%]), followed by catered events (126 outbreaks [15.4%]), the home (83 outbreaks [10.2%]), schools and day care centers (49 [6.0%]), and health care institutions (43 outbreaks [5.3%]). However, many cases resulted from relatively few outbreaks (<30 each) associated with community events (9,726), processing plants (8,580), mobile/temporary service (5,367), and camps/armed forces (5,117). The single most frequently reported setting was restaurants, with 324 outbreaks and 16,938 cases. Improper hygienic practices in homes, on picnics, or at community events accounted for 89 of the 816 outbreaks. There were 18 outbreaks associated with commercial travel in air flights, trains, and cruise ships over several decades, although only the last seems to be a major concern today. Sixteen outbreaks occurred where food, primarily produce, was harvested and shipped from one country to another. Sometimes the presence of an infected worker preparing food was only one of several factors contributing to the outbreak.

This article is the second in a series of several reviewing the role of food workers in foodborne outbreaks. The rationale for concern over foodborne outbreaks arising from workers infected with agents such as norovirus, hepatitis A virus (HAV), *Salmonella,* and *Shigella* has previously been presented *(32).* These data show that there have been increasing numbers of outbreaks during the past two decades over previous years. There may also be increased opportunities for infections to spread through trade of food and travel to other countries. This article presents and discusses data on some of the largest outbreaks, the numbers of hospitalized persons and deaths, and the different settings of food service establishments, including commercial travel where these outbreaks occurred.

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METHODS

A description of the database of the 816 outbreaks implicating food workers and the criteria used for collecting and collating are described in Greig et al. *(32).*

RESULTS

Large outbreaks where food workers were implicated. Food workers have been responsible for, or at least contributory to, some very large outbreaks where food was served at extensive gatherings, usually over a period of time (Table 1). A good example is the 1987 Rainbow gathering in North Carolina *(95)*; *Shigella* spread through many thousands of participants via water, food, and person-to-person spread. Although it was impossible to determine the precise extent of secondary spread, it was extensive. Another example occurred at a Michigan music festival in 1988 *(56),* where tofu salad contaminated by infected food workers

TABLE 1. *Outbreaks involving food workers with over 1,000 cases*

Food	Agents	Cases	Narratives	Reference
Multiple foods	*Shigella sonnei*	6,350	1987, North Carolina: For 2 wk, food was prepared in 47 communal kitchens in a national forest area for a Rainbow gathering. No toilets, hand washing facilities, safe drinking water sources, or refrigeration was available. The outbreak began on 4 July and rapidly spread throughout the gathering until it was closed on 15 July. Transmission was assumed to be by food, water, and person-to-person contact. Secondary infections ocurred after ill persons returned to home communities in other parts of the United States	*95*
Multiple foods	*Staphylococcus aureus*	4,000	1998, Brazil: 8,000 people gathered in a community to celebrate a Catholic priest's ordination. After eating food provided, there were 4,000 acutely ill persons and 2,000 hospitalizations. Sixteen persons died. The food was prepared over 2 days and left at room temperature for 1 day	*19*
Multiple foods	Norovirus	3,353	1989, Japan: 3,236 (41.5%) of 7,801 schoolchildren and 117 (39.4%) of 297 teachers were ill. Food had been provided by a catering company to nine elementary schools. Workers had bare-hand contact with the food, and a worker reported symptoms of gastrointestinal illness on the day the food was prepared	*51*
Tofu	*Shigella sonnei*	3,175	1988, Michigan: An outbreak of *Shigella* occurred among 563 staff responsible for setting up the festival. Because infected persons responded to treatment, the organizers proceeded with the festival. During the event, announcements alerted the participants of the risks of shigellosis, and bleach hand washing solutions were provided for disinfection near the toilets; however, few responded because the water looked dirty. 278 staff and 2,897 attendees were estimated to be ill. Fifty volunteers, many of whom lacked training in proper food handling techniques, prepared the tofu salad. Some workers prepared food while they were ill and likely contaminated the salad ingredients. Refrigeration of large batches may not have been sufficient to prevent growth of *Shigella*. Large crowds made person-to-person spread particularly easy, many cases were secondary in nature	*56*
Frosting	Norovirus	3,000	1982, Minnesota: A bakery worker prepared 76 liters of frosting using his arm up to the elbow to break sugar lumps and scrape the sides of the vat. He had five episodes of diarrhea and two of vomiting during his 6-h shift when he frosted the cakes. Also he had sick children at home	*52*
Cake	Norovirus	2,700	2002, Massachusetts: A cake requiring direct hand contact during its preparation was associated with the majority of illnesses. At least two bakery employees experienced norovirus-compatible illness during the week preceding the weddings. Two wedding guests, a wedding hall employee, and one of the bakery employees were ill; identical sequence types were detected in the stool specimens submitted	*26*
Vegetables	*Vibrio cholerae*	1,931	1990, Mozambican refugees in Malawi, Africa: Hands were placed into stored household drinking water, and there was improper reheating of leftover food	*79*
Mayonnaise	*Salmonella* Typhimurium	1,800	1976, Finland and Las Palmas in several charter flights: *Salmonella* Typhimurium phage type 96 was isolated from passengers, mayonnaise, and one food worker in the Las Palmas catering establishment	*39*
Raspberries	*Cyclospora cayetanensis*	1,465	1996, 20 states and Washington, D.C., and two Canadian provinces: At least 55 events were provided raspberries from as few as five Guatemalan farms. Investigation revealed that there were no hand washing facilities and that the water supply was contaminated	*41*
Tuna salad containing eggs	*Streptococcus* group A	1,200	1968 at a military base in the United States: 111 cadets were hospitalized during an outbreak due to secondary spread resulting from close contact. One food worker who shelled boiled eggs was asymptomatic but had a positive throat culture during the investigation	*43*
Hamburger	*Shigella flexneri*	1,136	1984, at a resort in Haiti: A butcher who prepared hamburger patties had a *Shigella* infection and continued working while ill during the 3-week period in which guests reported illness. Illnesses were linked only to those who consumed raw or rare hamburger; this was followed by secondary person-to-person spread between roomates	*77*

TABLE 2. *Summary of outbreaks resulting in hospitalization involving food workers*

Agent	No. of outbreaks	No. of cases	No. hospitalized	% hospitalized
Staphylococcus aureus	8	4,383	2,180	49.7
Salmonella (nontyphoidal)	8	1,876	84	4.5
Yersinia enterocolitica	3	247	45	18.2
Hepatitis A virus	3	337	177	52.5
Norovirus	2	178	113	63.5
Salmonella Typhi	2	85	24	28.2
Streptococcus group A	1	1,200	111	9.3
Shigella sonnei	1	32	5	15.6
Cyclospora cayetanensis	1	87	1	1.1
Total	29	8,425	2,740	32.5

TABLE 3. *Outbreaks with the largest numbers of hospitalized cases involving food workers*

Agent	No. of outbreaks	No. of cases	No. hospitalized	% hospitalized
Staphylococcus aureus		25	7	28.0
		35	8	22.9
		69	11	15.9
		5	3	60.0
		195	144	73.9
		36	5	13.9
		4,000	2,000	50.0
		18	2	11.1
Subtotal	8	4,383	2,180	49.7
Salmonella (nontyphoidal)		866	2	0.2
		78	1	1.2
		14	1	7.1
		751	45	6.0
		50	14	28.0
		80	15	18.7
		21	2	9.5
		16	4	25.0
Subtotal	8	1,876	84	4.5
Yersinia enterocolitica		50	2	4.0
		159	7	4.4
		38	36	94.7
Subtotal	3	247	45	18.2
Hepatitis A virus		180	6	3.3
		133	133	100.0
		24	5	20.8
Subtotal	3	337	177	52.5
Norovirus		130	108	83
		48	5	10.4
Subtotal	2	178	113	63.5
Salmonella Typhi		67	21	31.3
		18	3	16.6
Subtotal	2	85	24	28.2
Streptococcus group A	1	1,200	111	9.3
Shigella sonnei	1	32	5	15.6
Cyclospora cayetanensis	1	87	1	1.1
Total	29	8,425	2,740	100.0

resulted in 3,175 cases of shigellosis over a 3-week period. At a resort in Haiti *(77),* a worker with shigellosis transmitted the disease to 1,136 guests, again over a 3-week period. An even larger episode occurred in Japan *(51),* when thousands of schoolchildren ate meals contaminated with norovirus prepared in a central commissary. In a different situation, Mozambican refugees in Malawian camp *(79)* were infected with cholera via contaminated water and food for an undetermined time.

In general, salads (potato, egg, turkey, tofu, and tuna) were the foods most frequently involved in the larger outbreaks. These were contaminated with norovirus, *Salmonella, Shigella,* and *Streptococcus.* Boiled eggs contaminated by a carrier of *Streptococcus* group A caused illness in 1,200 cadets at a military base *(43)* following consumption of tuna salad containing eggs. Commercially baked products, with wide distribution, were also responsible for many cases. Cake frosting contaminated with norovirus caused 3,000 cases in 1982 in Minnesota *(52),* over 1,000 cases in Georgia in 2000 *(53),* and 2,700 cases in 2002 in Massachusetts *(26)*; these outbreaks resulted from infected workers who contaminated icing during preparation through hand contact.

The largest outbreak documented in this study occurred in 1998 in Brazil *(19).* About 8,000 labor workers and their families attended a Catholic priest's Sunday ordination ceremony in the state of Minas Gerais, which was followed by a reception with a meal. Less than 4 h later, approximately 4,000 individuals experienced intense nausea, vomiting, diarrhea, abdominal pain, prostration, and dizziness. A chaotic situation resulted, with 81 patients admitted to the intensive care units of 26 local hospitals. Sixteen of the youngest and oldest of these intensive care unit patients died (<5 years and >65 years old). Eight food workers began preparing the chicken, roast beef, rice, and beans over 48 h on the Friday before the event. The majority of the entrees were stored in aluminum containers at room temperature until Sunday morning. These food workers had positive fingernail swabs for *Staphylococcus aureus,* and five of them had the same strain isolated from their nasopharynxes. Leftover food was also found to contain *S. aureus* at 2.0×10^8 CFU/g, which produced 6 μg of enterotoxin A/g, an exceedingly high level. This outbreak demonstrates that, given sufficient time and temperature abuse, *S. aureus* toxin production can have dire consequences.

Another very large outbreak of *Salmonella* Typhimurium with an estimated 1,800 cases involved passengers on several flights between Finland and the Canary Islands *(98).* These and other large outbreaks are discussed in more detail in other sections of the article.

Hospitalized persons and deaths associated with outbreaks. Of the reported persons affected by the outbreaks, 2,740 (3.4%) required hospitalization (Tables 2 through 4), and 98 (0.12%) died (Table 5). In 29 (3.5%) of the 816 outbreaks, at least one individual required hospitalization. The 11 outbreaks with the most persons requiring hospital treatment, totaling 2,678 individuals, are listed in Table 4. The agents involved in causing serious illness that required institutionalized care and treatment include not

TABLE 4. *Outbreaks with the largest numbers of hospitalized cases involving food workers*

Food	Agents	No. hospitalized	Narratives	Reference(s)
Multiple foods	*Staphylococcus aureus*	2,000	In Minas Gerais, Brazil, 8,000 gathered to celebrate a Catholic priest's ordination. 4,000 were acutely ill. Food was prepared over 2 days and left at room temperature before consumption	*19*
Fruit salad	Hepatitis A virus	166	An outbreak at a military base in California was associated with salads and grapefruits. The index case was a food worker preparing salads and slicing cantaloupes and grapefruit on 1 day. During this time, he experienced vomiting and diarrhea and washed his hands after each episode. He was allowed to return to kitchen duties 2 days later and remained there, preparing coleslaw, even though he was unwell for 4 more days	*44*
Egg and ham dishes	*S. aureus*	143	An outbreak associated with a commercial flight from Tokyo to Copenhagen resulted when a cook with open cuts, sores, and a finger lesion handled cooked ham. Ham was then left at ambient temperatures for 6 h before refrigeration	*7, 21*
Salad sandwiches	Norovirus	130	Nurses and housekeeping staff at a nurses' hostel in India were ill following consumption of salad sandwiches	*29*
Tuna salad	*Streptococcus* group A	111	During an outbreak at a U.S. military base, a secondary spread occurred among cadets because of close contact. One of the food workers who shelled boiled eggs was asymptomatic but had a positive throat culture during the investigation	*43*
Salad	*Salmonella* Typhimurium	45	A large community outbreak of salmonellosis was caused by intentional contamination of restaurant salad bars by multiple persons in Oregon	*91*
Milk, chocolate	*Yersinia enterocolitica*	36	An outbreak caused by *Yersinia* was associated with school cafeterias in the United States when chocolate was hand mixed in an open vat with bare hands	*4*
Orange juice	*Salmonella* Typhi	21	At a New York hotel, a food worker originally from Central America and another asymptomatic food worker contaminated the juice. The juice container and paddle to stir it with were found stored in the restroom	*3*
Unknown	*Salmonella* Enteritidis	15	Illnesses occurred throughout the Gaspé region of Quebec and New Brunswick, mainly among tourists. Seven food workers were also ill and excreted the organism. Probably some food or ingredient widely distributed in the region was responsible, combined with cross-contamination to other foods and subsequent careless handling, of which there was evidence	*85*
Sandwiches	*S. aureus*	11	The outbreak was associated with home caterers for a senior citizens' home in Quebec. *S. aureus* was recovered from stools, vomitus, egg sandwiches, and an infected finger of a food worker who prepared sandwiches, which were stored for 8 to 10 h without refrigeration. Other food workers were infected	*85*

only the not-unexpected *Salmonella* Typhi, *Yersinia enterocolitica,* and HAV, but also agents typically thought to cause mild illness, e.g., *S. aureus* (eight outbreaks) and norovirus (two outbreaks) (Table 2). In relatively few outbreaks were people seriously ill, but the one with the most hospitalized persons (2,000) also had the second greatest number of deaths (16). Typically, we know nothing about the dose consumed by the hospitalized persons in the 11 outbreaks, but it either must be assumed to be high or else the individuals were not resistant to infections because of lowered immunity. We know, however, that in the Brazilian *S. aureus* outbreak, very high levels of enterotoxin A were produced *(19).*

The episodes with the greatest number of deaths are briefly described in Table 5, and some are further amplified below. Over 1,900 Mozambican refugees in Malawi suffered from cholera, and 68 died *(79). Vibrio cholerae* spread from person to person both directly and through contaminated hands in water containers and improper reheating of leftovers. Infection with *V. cholerae* results in high morbidity because of the rapid onset of disease and then the debilitating dehydration that occurs within hours of onset. In a camp setting, with malnourished refugees, affected persons could easily be missed by overworked physicians and not receive critical medical attention in time. The outbreak with the second largest number of deaths was at a reception following an ordination service in Brazil, previously described *(19).* A catering company in the Canary Islands was responsible for 1,800 cases of salmonellosis and three deaths among Finnish tourists in 1976 *(39).* Eight years

TABLE 5. *Deaths resulting from outbreaks associated with food workers*

Food	Agent	No. of deaths	Narrative	Reference
Vegetables	*Vibrio cholerae*	68	Outbreak among Mozambican refugees in Malawi, Africa, 1,931 cases: Food workers placed their hands in stored household drinking water, and there was improper reheating of leftovers	*79*
Multiple foods	*Staphylococcus aureus*	16	Minas Gerais, Brazil: 8,000 gathered to celebrate a Catholic priest's ordination and ate food prepared over 2 days and left at room temperature for the duration	*19*
Aspic glaze	*Salmonella* Enteritidis	2	British Airways flights in 1984 with a total of 866 cases: 631 passengers, 135 aircrew, and 100 catering personnel and loaders. Two passengers died. A large number of airline staff had recently traveled overseas. An ill chef prepared the aspic glaze, which was then left at ambient temperatures. Also, it was reported that a party given by a senior catering manager at the catering center resulted in all guests becoming ill, with two hospitalized. The number of persons hospitalized was not reported for the airline cases	*5*
Unknown	*V. cholerae*	5	Nursing home in Singapore in 1984, 96 cases: A symptomatic food worker initiated the outbreak, but an asymptomatic colleague may also have contributed. Poor kitchen hygiene and toilets overflowing with sewage were observed. Flies were seen in the kitchen	*30*
Egg-mayonnaise salad	*Salmonella* Typhimurium phage type 96	3	Airplane (to and from Canary Islands to Finland, 1976), about 1,800 cases in several charter flights: *Salmonella* Typhimurium phage type 96 was isolated from passengers, mayonnaise, and one food worker in the Las Palmas catering establishment	*39*
Salad	Hepatitis A virus	2	Restaurant outbreak in Missouri resulting in 110 cases: Four waitresses were infected, and two patrons died. The index case unpacked produce and prepared lettuce for salads	*13*
Stuffed eggs	*V. cholerae*	1	Flight from London to Bahrain to Sydney, 47 cases: Two food workers were culture positive 2 wk after the outbreak (both denied illness); one helped prepare the hors d'oeuvres. A cholera outbreak had begun in Bahrain 2 wk before this outbreak	*78*
Eggs	*Streptococcus* group A	1	Church party in Sweden, 122 cases: The cases resulted from consumption of food or leftovers from a church party. Six of seven food workers were positive for the agent. The food was temperature abused	*16*

later, a similar problem occurred when a chef, at a different catering company, was infected with *Salmonella* Enteritidis and prepared aspic to glaze hors d'oeuvres served on several flights of a major airline. The aspic was left at ambient temperatures and resulted in a total of 631 passengers, 135 aircrew, and 100 catering staff and loaders becoming infected; 2 passengers died *(5).* In a Missouri restaurant, patrons ate salads contaminated with HAV, resulting in 110 infected persons, including 4 waitresses; 2 patrons died *(13).* A food worker, the index case, unpacked produce and prepared lettuce for the salads. Two other outbreaks had single deaths—one from cholera *(78)* and the other from *Streptococcus* group A *(16).* In these last two outbreaks and the one involving Finnish tourists, egg dishes were temperature abused.

Fatality rates were calculated for the appropriate pathogens: *V. cholerae* with three outbreaks and 2,074 cases (range, 2.13 to 3.52; median, 3.5; mean, 3.6); *Salmonella* with two outbreaks and 2,666 cases (median, 0.2; mean, 0.2); and HAV (110 cases), *Streptococcus* (122 cases), and *S. aureus* (4,000 cases) with one outbreak each had fatality rates of 1.8, 0.8, and 0.4, respectively.

Settings where food workers have been implicated in outbreaks. Outbreaks linked to food workers have occurred in a variety of settings, including the food service sector, catering, health care, schools and day care centers, prisons, retail establishments, processing facilities, homes, community events, armed forces, and camps. These are discussed separately in the following sections and summarized in Table 6.

Outbreaks involving food service establishments, including restaurants, hotels, and cafeterias. There were 376 outbreaks with 22,870 cases associated with food served in food service facilities. The specific breakdown for the food service facilities was restaurants (324 [39.7%]), hotels (32 [3.9%]), and cafeterias (12 [1.5%]). Relatively few outbreaks involving infected food workers occurred in facilities serving so-called ethnic foods—the foods were

TABLE 6. *Settings where outbreaks have occurred involving food workers*

Category	Settings	No. of outbreaks (%)	No. of cases (%)
Food service facilities	Restaurant	324 (39.7)	16,938 (21.0)
	Hotel	32 (3.9)	3,625 (4.5)
	Cafeteria	12 (1.5)	763 (0.9)
	Private club and resort	8 (1.0)	1,544 (1.9)
Total		376 (46.1)	22,870 (28.3)
Mobile or temporary service	Church social events	19 (2.3)	4,803 (6.0)
	Meals-on-wheels	1 (0.1)	400 (0.5)
	Fair/festival	1 (0.1)	85 (0.1)
	Mobile food service	1 (0.1)	42 (0.1)
	Temporary food service	1 (0.1)	34 (<0.0)
	Vending machine	1 (0.1)	3 (<0.0)
Total		24 (2.9)	5,367 (6.7)
Catered events	Conference or other function	104 (12.7)	8,141 (10.1)
	Workplace	13 (1.6)	1,309 (1.6)
	Wedding meals	9 (1.1)	337 (0.4)
Total		126 (15.4)	9,787 (12.1)
Health care institutions	Hospitals	21 (2.6)	1,739 (2.2)
	Other institutions	12 (1.5)	1,127 (1.4)
	Nursing homes	10 (1.2)	1,069 (1.3)
Total		43 (5.3)	3,935 (4.9)
Child care	Schools	45 (5.5)	7,163 (8.9)
	Day care facilities	4 (0.5)	259 (0.3)
Total		49 (6.0)	7,422 (9.2)
Camps and armed forces bases	Camps	19 (2.3)	1,416 (1.8)
	Military base	9 (1.1)	1,770 (2.2)
	Refugee camp	1 (0.1)	1,931 (2.4)
Total		29 (3.6)	5,117 (6.3)
Prisons and jails	Prisons and jails	4 (0.5)	757 (0.9)
Community events	Native American Indian reservation	3 (0.4)	153 (0.2)
	Rainbow gathering	1 (0.1)	6,350 (7.9)
	Music festival	1 (0.1)	3,175 (3.9)
	Amish community	1 (0.1)	48 (0.1)
Total		6 (0.7)	9,726 (12.1)
Home-related activities	Private events in the home	78 (9.6)	2,179 (2.7)
	Picnics	5 (0.6)	144 (0.2)
Total		83 (10.2)	2,323 (2.9)
Commercial travel	Airplane	12 (1.5)	2,824 (3.5)
	Cruise ship	4 (0.5)	816 (1.0)
	Train	3 (0.4)	165 (0.2)
Total		19 (2.3)	3,805 (4.7)
Retail food outlets	Supermarket	11 (1.3)	208 (0.3)
	Butcher shop	1 (0.1)	59 (0.1)
Total		12 (1.5)	267 (0.3)
Processing plants	Bakery	18 (2.2)	7,613 (9.4)
	Processing plant	6 (0.7)	967 (1.2)
Total		24 (2.9)	8,580 (10.6)
Unknown location		21 (2.6)	726 (0.9)
Overall total		816 (100.0)	80,682 (100.0)

documented as Mexican or Chinese (nine and two outbreaks, respectively).

Norovirus caused more food service–associated outbreaks (274) by contamination of food from workers than any other agent. In 130 (47.4%) of these, the food worker was symptomatic while working. Of 151 outbreaks associated with *Salmonella,* 81 (53.6%) involved known infected food workers. Of the 84 HAV outbreaks, 14 were associated with asymptomatic food workers, and another 17 were associated with workers who became ill.

Four laboratory-confirmed cases of norovirus infection were associated with dining at a Minnesota restaurant on 27 February and 2 March 2004 *(65).* Two employees had contact with an ill child, and both worked shifts at the restaurant during the 2 weeks that the child had diarrhea. Another employee reported vomiting and diarrhea beginning on 20 February but worked a shift each day from 19 to 21 February, preparing ready-to-eat (RTE) foods. Bare-hand contact was reported for the slicing of bread and preparation of oil, garlic, and Parmesan cheese for dipping. The investigation determined that the outbreak was caused by either the recently ill employee or worker contact with ill household members.

In December 2001, there were 28 cases of *Salmonella* Typhimurium phage type 64 variant associated with the consumption of mango pudding and pickled Chinese cabbage at a Korean-style restaurant in metropolitan Adelaide, Australia *(45).* A culture-positive food worker reported the onset of gastrointestinal symptoms 2 days before the affected patrons reported illness; the worker's sole responsibility was the preparation of the mango pudding. This was the only food not prepared in the kitchen; it was made daily from gelatin and sliced, fresh mangoes on a small bench space at the back of the kitchen. The restaurant had no designated hand washing facilities. This outbreak alerted local authorities to contact all Asian and multicultural restaurants regarding safe food preparation and handling practices.

An outbreak of HAV in a cafeteria in New York in

November 1981 associated with the consumption of cold, sliced meat sandwiches resulted in 37 affected patrons. One employee was symptomatic and had immunoglobulin M (IgM) antibodies to HAV. He was considered the index case because of the timing of his illness, and he had prepared the sliced meat sandwiches *(37).* Although he had sought medical care, physicians did not report the case to the health department.

A large outbreak of 203 cases occurred after an HAV-infected food worker contaminated food at a drive-in restaurant in Oklahoma *(10).* Although he developed diarrhea, he reported good hand washing practices and continued handling food for 4 days until the onset of jaundice. In another outbreak of 80 cases, an employee excreting *Salmonella* Typhi used bare hands to remove meat from the steamed bovine heads used in a barbacoa dish (a mixture of muscle, lips, ears, tongue, and eyes from steamed bovine heads) served in a Mexican food take-out restaurant *(82).*

In August 1996, a wedding reception in a North Yorkshire hotel resulted in 111 cases of viral gastroenteritis with an attack rate of 50% *(68).* Laboratory analysis confirmed small round structured virus genotype II as the agent. A kitchen assistant suddenly became ill on the evening prior to the reception, vomited into a kitchen sink, and subsequently cleaned it with a chlorine-based disinfectant. The next morning, the sink was used to prepare potato salad, which was epidemiologically linked to the illness.

An unusual outbreak occurred in Oregon in 1984 over 2 months when restaurant salad bars were deliberately contaminated with *Salmonella* cultures by multiple persons from a religious sect at a commune and infected 751 patrons and food workers *(91).* The cultures were prepared in a clandestine laboratory and poured on salad items or in coffee creamers. Most cases were associated with 10 restaurants, and the workers there who became infected may have contributed to the spread of the infection by continuing to work while ill until the health department excluded them. A lack of soap and hand towels in the washroom was also noted at one of the restaurants, further contributing to the outbreak. The *Salmonella* strain later found in the commune was identical to the outbreak strain.

Relatively few outbreaks were associated with mobile or temporary service facilities. In one of these in Austria, the investigation showed that potato salad prepared for a fair caused 85 cases of salmonellosis *(75).* Molecular epidemiology showed that isolates from eggs, from the egg-laying flock, and from the infected persons were indistinguishable. It was hypothesized that cross-contamination from eggs contaminated with *Salmonella* Enteritidis to boiled potatoes occurred in the kitchen area, where raw eggs were handled by village residents preparing a traditional Viennese egg dressing for the meat dishes. Unrefrigerated storage of peeled potatoes may have favored bacterial growth.

Six outbreaks with 400 cases of norovirus all resulted from Polish raspberries served on meals-on-wheels meals, although there were different strains in the products that came from different suppliers and importers *(23).* The hypothesis was that several independent contamination events took place to explain the heterogeneous distribution of norovirus strains in the shipment to Denmark. Human fecal contamination was the source, but it could have been from infected farm or processing workers or contaminated irrigation water.

Vending machines are generally thought to provide safe food products. However, an outbreak occurred in 1976, when 11 employees of a Denver business used a vending machine on the premises and suffered from staphylococcal food poisoning. Three other employees at another site in town were also affected. The firm preparing the vended food had provided hot Greek spaghetti for 16 businesses at 29 vending locations in Denver. Two of 10 employees who prepared the spaghetti reported illness a few hours after eating some of the spaghetti the day before; *S. aureus* was cultured from the hands of one of these workers. His hands were bandaged because of an infection, and bare hands were routinely used during food preparation. Enterotoxin D was found in the products from both machines linked to illnesses, indicating that the *S. aureus* had sufficient time to grow (*S. aureus* [$>10^5$ CFU/g on analysis]) and produce the toxin in the spaghetti before it was put into the machines. The investigation revealed that the cooler at the catering company used for storing ingredients and RTE food allowed the growth of pathogens for up to 8 h during the spaghetti preparation *(8).*

Outbreaks involving catered events, including conferences, wedding receptions, and workplaces. Catering for large numbers of guests can be challenging, both from a logistics point of view and from a food safety perspective. Much of the preparation must be done in advance when large groups need to be served in a relatively short time. Most catered foods are prepared at times when regulators do not perform inspections. In addition, the workers may be inadequately trained, poorly supervised, and poorly paid, without any sick leave benefits; hence, they may be more likely to work when ill.

There were 97 undefined catered events caused mainly by norovirus or probable norovirus (53) and *Salmonella* (18). Nine additional catered events occurred at wedding receptions and seven at conferences, again with the majority involving norovirus. A Kentucky health department received a report of a catering company food worker with HAV in October 1994 *(59).* After an extensive investigation, 91 cases were identified from a number of settings catered by the company. At least one case was reported from 21 (51%) of the 41 catered events, with an overall attack rate of 7% among the 1,318 known attendees. Risk factors identified with the events included lack of on-site sinks or kitchens. At three venues with high attack rates, eating at least one of several uncooked foods was associated with illness. The infected food worker who had prepared many of the uncooked foods served at these catered events apparently had good hygiene and had not reported diarrhea. It is difficult to prevent such a carrier from preparing food without expensive regular screening. Many catered meals have caused multiple illnesses before the cause was identified. At a wedding reception in Minnesota in

2004, a norovirus outbreak of 31 persons was almost certainly spread by ill guests to others by vomiting during the wedding reception *(65).* Three of the 200 guests were ill with gastroenteritis during the week before the wedding, and several more had illnesses in family members. Most people ate buffet style, but the head table was given plated meals. None of the foods served were statistically associated with illness. During the serving of the buffet, there were multiple episodes of vomiting by guests. The caterers were interviewed, and none of them had prior illness in themselves or their family members. However, one food worker who worked on the buffet line was sick 2 days after the wedding reception (victim). Going through the buffet line was an elevated risk, but even sitting at the head table was not protective, indicating how easily the norovirus can spread.

In March 2000, 18 of 200 Queensland club luncheon guests suffered from *S. aureus* food poisoning after the consumption of catered chicken *(17).* The ill persons were all elderly. Whole chickens cooked at 200°C for 50 min by a butcher-delicatessen were kept in two separate batches and stored in hot boxes at 45°C for 3 to 4 h. Transportation to the event site took a further 50 min to an iced cold room. Later, the caterer removed the chickens from the cold room and quartered them by hand, with a common tea towel to dry hands. The chicken was consumed the following day. Levels of $>2.5 \times 10^6$ *S. aureus* CFU/g were found in five chicken samples, and enterotoxin was found in four of five leftover plates. Pulsed-field gel electrophoresis demonstrated genetic relatedness between the food and human isolates of *S. aureus.* There was ample opportunity for growth of the pathogen to produce enterotoxin, but the source of the *S. aureus* was not determined, although it most likely came from the hands of the worker, the towel, or the equipment used.

The following two examples show how illnesses occurred at work settings but in different ways and with different agents. In April 1981, an outbreak of hepatitis A occurred among four state legislators, two lobbyists, and one senate page in Nashville, Tennessee *(35).* As part of a follow-up investigation, 1,079 persons received immune globulin, and 711 had blood drawn for diagnostic testing. From this surveillance study, one extra person (a secretary) was identified, but she was not the source. The Tennessee Department of Public Health traced the source to a food worker who was responsible for cutting wheels of cheese and chubs of bologna. The worker then had distributed the items to various rooms in the capitol and other buildings, including a hospitality suite. All the infected persons, except for the page, had eaten at the hospitality suite, but he had consumed a large quantity of cheese at the clerk's office one evening. The worker had served about 100 persons over several days, especially at the hospitality suite, even though he was symptomatic (he experienced headache, nausea, and malaise, and his eyes were slightly yellow) at the time.

In September 2005, a cluster of acute gastroenteritis cases with vomiting and diarrhea was reported to a public health department in southern Austria *(55).* All 120 persons affected were staff at a factory manufacturing electrical appliances that employed 1,357 workers. A point-source outbreak involving food served to these workers was likely, and a female catering company staff member reported having been ill from 2 days before the outbreak. She had prepared sandwiches without wearing gloves during that time. Further investigation revealed that one of the cooks at the catering company had become ill 3 days earlier, while other catering staff became ill at the same time or after the factory workers. Identical strains of norovirus were found in the stools of both ill employees and catering staff.

Outbreaks involving camps and armed forces bases. The risk of foodborne illness at industrial or summer camps may be considered higher than at most food service establishments. Camps may cause foodborne outbreaks because of frequent overcrowding in kitchens, inexperienced staff, and poor hygienic conditions *(69).* We record 19 outbreaks with 1,416 infected persons (15 hospitalized) where food workers at camps were associated with illnesses. Physical facilities for cooking, storing, and serving food may be limited, with the potential for improper cooling of food *(90).* Over a 6-year period from 1974 to 1979, three outbreaks occurred in industrial camps in western Canada associated with *S. aureus* from kitchen crews who prepared and served hamburgers and other meats. Identical strains were isolated from nasal swabs and a cut finger *(84, 86, 87).* Sixteen outbreaks occurred in summer recreational camps associated with workers who appeared to have unintentionally contaminated food with probable norovirus (five), *Campylobacter* (two), *Y. enterocolitica* (three), *Salmonella* (two), *Shigella* (two), *Escherichia coli* O157:H7 (one), and rotavirus (one). One of these in 1987 was an outbreak of bloody diarrhea reported in 16 of 305 campers and was associated with *E. coli* O157:H7 at an Ontario camp; some secondary transmission was reported *(88).* Although a food worker was infected, there were compounding factors: inadequate cleaning and sanitizing of the meat slicer, cross-contamination, temperature abuse, and undercooking of meat. Another outbreak occurred at a weight reduction camp because milk was contaminated when malfunctioning spigots on 6-gal (22.71-liter) reconstituted powdered milk storage containers were repaired. On at least three occasions, the head cook placed his hand into a partly filled container to plug the hole while the spigot was replaced, resulting in 159 campers becoming infected with *Y. enterocolitica (66).* More information on outbreaks and hygienic ways of preparing and storing food while camping and during other recreational activities can be found in Todd *(90).* In a different kind of camp previously described, nearly 2,000 Mozambican refugees in a tightly packed area in Malawi suffered from cholera when the food and water supply became contaminated, and an undetermined number of secondary cases occurred *(79).*

Outbreaks in the armed forces and industrial or recreational camps may not always be reported, because the camps tend to be self-regulated and are less likely to have regular food inspections. Nine outbreaks, involving all branches of the armed forces, affected 1,770 individuals

and resulted in the hospitalization of 277; these were traced to improper food worker hygiene. In three of the outbreaks (army and air force), workers infected with *Streptococcus pyogenes* group A contaminated salads (boiled egg and tuna) by sneezing or handling the ingredients. Streptococcal outbreaks are infrequently documented, and most in this study occurred many decades ago. However, excretions on hands after sneezing or coughing from an asymptomatic infection can easily contaminate food and cause pharyngitis. Levy et al. *(57)* tabulated all known group A streptococcal infections that had previously occurred in military bases, nursing homes, and community picnics. Food workers were implicated in 21 of 35 listed outbreaks from 1941 to 1997. An outbreak during a military field training exercise resulted when a cook's aid, infected with HAV, served lettuce and fruit punch, causing illness in 22 soldiers *(73).* In another armed forces outbreak, an asymptomatic HAV carrier contaminated fruit salad, resulting in 133 infections among 2,781 sailors *(44).* Cholera was more a military hazard in the past, but recently in 1997, two food workers with *V. cholerae* infected nine soldiers in Delhi, India *(83).* In 1961, 23 cases of HAV occurred in officers at a U.S. Naval base and were attributed to potato salad prepared by a symptomatic worker with a personality disorder. He had deliberately urinated in the potato salad as an act of defiance but did not know he was transmitting the virus *(47).*

Outbreaks involving inmate food workers in prisons and jails. Two outbreaks each occurred at jails (470 cases) and prisons (287 cases). Two outbreaks in prisons in New York and Florida occurred because inmates assigned to kitchen duties were *Salmonella* or *S. aureus* carriers. In 1987, an extended outbreak of salmonellosis occurred at New York's Rikers Island Correctional Institution for Women *(2).* The investigation was difficult because no particular food was implicated, and inmates were not always cooperative or had poor recall of what they had eaten. In addition, there was high inmate turnover, and the Rikers Island Health Services conducting the investigation had no jurisdiction in the kitchen to take food or environmental samples or stool specimens of those who were ill. However, kitchen jobs are highly desirable among inmates, and some may have been working there without Rikers Island Health Services clearance. Kitchen workers were screened for illness, and those found positive were excluded. A cook whose work schedule was related to peak incidence of illness was found to be a carrier, and she had contaminated food, although specific items could not be identified. Four other workers were positive for two different *Salmonella* serotypes, indicating probably more than one source of contamination over a period of time. In 1990, many of the 474 inmates in a Florida prison experienced gastroenteritis, and 331 were interviewed *(61).* Turkey served for an evening meal was associated with illness in two waves, one beginning about 4 h and another 8 h after the meal. These two events may have been triggered by the ingestion of two separate agents, which have different incubation periods. In fact, *Salmonella* and *S. aureus* (at 3.1×10^7 CFU/g) were both isolated from the leftover turkey. However, only *S. aureus* was cultured from the inmate food worker who had deboned the turkey with his hands. Although he claimed to have worn wrist-high gloves while deboning, he had multiple excoriated lesions on his forearms. The investigators assumed that the *Salmonella* came from the uncooked turkey carcasses. Because the turkey meat was held unrefrigerated for several hours, rapid multiplication of the two pathogens occurred, and reheating the deboned meat with gravy was insufficient to destroy the *Salmonella* and the heat-stable enterotoxin produced by the *S. aureus.*

In 1999, in New South Wales, 72 inmates, who consumed curried egg salad sandwiches prepared in the prison kitchen, became infected with *S. pyogenes* group A and developed tonsillopharyngitis *(57).* Five inmates were assigned kitchen duties each day, and although all of these denied having lesions on their hands, a clinic staff member remembered dressing 5-day-old wounds for one of the food workers the day the eggs were prepared. This person had the same strain of *Streptococcus* isolated from skin lesions and throat. Although gloves were required for food workers, none were worn during the time of the facility inspection. Fifteen secondary cases were identified.

Outbreaks involving schools, colleges, universities, and day care centers. There were 45 ''school''-related outbreaks linked to food workers, four with universities or colleges, and four with day care centers. The largest incidents occurred in Japan, where school meals are regularly provided for pupils. The same menu is prepared from the same ingredients for all the students in a school or for many schools in an area. Centralized food production allows hundreds of children to be affected simultaneously if contamination occurs. From 1987 to 1996, there were 269 foodborne outbreaks recorded in Japan, and infected employees were a factor in nine (14.5%) of them *(63).* In four of the outbreaks, food workers contaminated rice, noodles, egg products, and salad with *S. aureus.* In 1989, 3,236 (41.5%) of 7,801 schoolchildren and 117 (39.4%) of 297 teachers were infected with norovirus in seven elementary schools in one Japanese city. Boiled vegetables with peanut butter were associated with the outbreak. One of 48 food workers who prepared the lunch experienced three episodes of vomiting and two of diarrhea and fever the day the meal was prepared and was considered the most likely source of the infection *(51).*

An outbreak of acute infectious viral gastroenteritis in 139 persons occurred in a high school in Maryland in 1984 *(33).* Some of the patients had high antibody titers to Norwalk virus (now known as norovirus). Eating sandwiches at the school cafeteria was significantly associated with illnesses in students, teachers, cafeteria workers, and construction workers. The cafeteria kitchen had a good inspection record, and no violations were observed on inspection following the outbreak, although the food workers did not wear gloves. The sandwiches consisted of one slice of cheese and a slice of sandwich meat on a bun. None of the other 10 schools serving these sandwiches experienced any unusual increase in gastroenteritis. Although the six cafe-

teria workers denied illness in themselves or their families, four were found to be symptomatic during the outbreak. One asymptomatic and two symptomatic workers prepared and ate the sandwiches. Another symptomatic worker, who had an eightfold rise in titer to Norwalk virus, placed sandwiches on plates without gloves. This could be the index case, because it is feasible that the worker was excreting the virus 36 h earlier. There were approximately 33 secondary cases in household contacts with ill persons.

An investigation was triggered when it was noted that, during September 1976, 13 of 28 appendectomies in one community in New York were performed on schoolchildren *(4).* Thirty-eight were diagnosed with gastroenteritis, eventually identified as yersiniosis, epidemiologically associated with drinking chocolate milk at school. *Y. enterocolitica* serotype O:8 was isolated from the milk in the school cafeteria and the stools of the affected persons. A follow-up questionnaire showed that approximately 222 children and 5 employees at five area schools who consumed the milk had typical yersiniosis symptoms (abdominal pain and fever occurring within 2 days of each other). The outbreak likely resulted from the method of chocolate milk production at the small dairy that supplied all the area schools. Chocolate syrup was added to pasteurized milk in a proportion of 1:10 in an open vat and mixed by hand with a stirring rod.

The factors that led to worker contamination in outbreaks related to schools and day care centers were similar to those in restaurants and other settings. These included symptomatic and asymptomatic intestinal illness, cuts or lesions on hands, improper hygiene, and inadequate washing facilities. An unusual outbreak occurred in New York when 225 students became ill with streptococcal pharyngitis after eating salad made with shrimp deveined by a food worker who had just been abroad *(22).* However, it is not known for certain that this worker acquired his infection from the overseas trip.

Day care centers are particularly vulnerable, because the caregivers are involved in food preparation and serving and cleaning up after infants and young children. There were four outbreaks in day care centers associated with infections from *Salmonella,* norovirus, probable norovirus (small round structured virus), and *Shigella.* The largest occurred in Sweden in 1999, with 195 cases of norovirus in 30 day care centers arising from pumpkin salads brought in by a caterer *(31).* Two workers preparing the salad were infected; one was asymptomatic, and the other was ill.

Outbreaks involving hospitals, nursing homes, and long-term care facilities. There were 43 reports of outbreaks with more than 3,935 cases associated with consumption of food at hospitals, nursing homes, and health care institutions. Outbreaks originating in kitchens for hospitals (21), long-term care facilities (10), or health care institutions (12) can have serious consequences because of the immunocompromised state of many patients. The etiological agents associated with health care facility workers were norovirus (18 outbreaks), *Salmonella* (8), *S. aureus* (5), HAV (2), *Streptococcus* group A (2), and *Giardia, Cyclospora,* and *V. cholerae* O1 (1 each). Implicated foods typically were RTE, such as sandwiches, salads, and fruit. In a hospital outbreak in Vermont, 44 clinical and 22 asymptomatic cases arose because of exposure to contaminated sandwiches *(62).* Two cafeteria employees had subclinical hepatitis and were the probable source. Seven other cases outside the hospital were also linked to consumption of the sandwiches. In another hospital outbreak with 80 cases, this time in Wales, untrained workers and patients with learning difficulties contaminated ham, coleslaw, bread rolls, cheese, and pineapple with norovirus *(25).* The food was mainly prepared in the kitchen but was also supplemented from food brought from homes and served buffet style. Two of the guests had diarrhea at the time of the buffet and were likely the source of norovirus infection rather than the kitchen staff, because those eating had handled the food. A culture-positive asymptomatic employee who mashed potatoes was identified as the source of a *Salmonella* Enteritidis outbreak in a Jordanian hospital in 1989 *(49).* The potatoes were peeled after boiling and mixed with milk with bare hands. In fact, a total of nine workers were found to be carriers during the investigation.

In the eight hospital outbreaks caused by *Salmonella,* three workers reported working while ill, and one had a sick child at home. Twenty-two patients and seven staff, on two wards in two English hospitals with shared catering facilities, became infected with *Salmonella* Enteritidis over a 19-day period in 1993 *(20).* Extensive food and environmental sampling failed to find the source of the *Salmonella.* However, fecal screening of asymptomatic staff showed a high carriage rate among those involved with catering (12.3%) versus those on the ward (2.2%). Although three of the chefs were positive, there was a clear association between illness and consumption of meals prepared by only one of the carriers. He had received a disciplinary warning for handling cooked food with his bare hands. The other carriers were assumed to be victims. Transmission was likely intermittent via prepared food; thus, the protracted outbreak appeared to be a nosocomial event. The outbreak ended when all of the food workers who were carriers were excluded from work in the kitchen. The cost of the outbreak was estimated at £33,000 (about $66,000) mainly for testing approximately 600 specimens, paying overtime for staff, and recovering the expense to the health care system of 54 extra hospital days for the patients.

An outbreak of cholera occurred in a home for the aged in Singapore in 1984, resulting in 96 infected residents and 5 deaths *(30).* The index case, a 72-year old resident, assisted in food preparation in the kitchen, even when he had diarrhea. The outbreak ceased when he became seriously ill and was hospitalized 5 days later. Another kitchen helper, who was deaf and mute, was found to be asymptomatic for *V. cholerae* O1 infection. Most of the residents were senile, and a case-control study could not be carried out to determine which specific foods had caused the illnesses. It is believed that most resident infections arose from food contaminated by these two workers, especially because the cooks and helpers did not practice proper food safety and personal hygiene, although no vibrio was isolated from foods or kitchen environments. It is unclear how the helpers

became infected and how the cholera was introduced into the kitchen; it could have been from food brought into the kitchen or from flies that were seen there during the investigation.

During a 6-week period in 1986, an outbreak of giardiasis occurred in residents (35) and employees (38) in a Minnesota residential home, as well as in children at a day care center (15) within the nursing home environment *(96).* Although there were multiple modes of transmission of *Giardia lamblia* within these groups, the main routes were foodborne and person to person. There was a significant association between sandwich consumption but not with cooked, pureed items and those ill at the nursing home. The most likely scenario is that the outbreak first occurred in the day care center, and the mother of one of the infected toddlers developed giardiasis but continued working as an employee in the food service area. She then infected other food workers, who in turn contaminated food served to residents and employees. The transmission within the day care center and beyond to family members and residents who were ''adoptive grandmothers'' was primarily person to person.

Outbreaks involving private events in the home, picnics, or church and community centers. Outbreaks that involve households, extended family gatherings, and outdoor events contributed substantially to the number of cases. Incidents in the home are rarely reported but may well be frequent. Ryan et al. *(74),* in a review of domestic home catering outbreaks, stated that of 101 outbreaks where food was prepared for large parties on domestic premises (birthdays, engagements, dinner parties, barbecues, and wedding receptions), 11 (10%) were associated with an infected food worker. Eight of these were caused by *Salmonella,* two were caused by norovirus, and one was of unknown origin. We found that there were 78 outbreaks associated with the home with 2,179 cases. Most of these outbreaks were caused by norovirus or probable norovirus (28 [35.9%]), *Salmonella* (16 [20.5%]), and *S. aureus* (10 [12.8%]). Nineteen outbreaks associated with social events organized by churches or similar groups resulted in 4,803 cases. Norovirus or probable norovirus was associated with 10 (52.6%) of these outbreaks. Concern has recently been expressed in Ontario, Canada, over such groups being allowed to operate without a license or training, because they occasionally have high-risk products on sale for charitable purposes *(27).*

Seventeen students and instructors at a graduation party in West Virginia in 1980 were acutely ill about 3 h after eating potato salad prepared at home *(9).* The investigation showed that the same *S. aureus* phage type was found in the potato salad and other foods as well as lesions on the hands of the food workers. The potato salad had been stored at room temperature for over 6 h and then kept above 7°C for another 17 h before it was served. This outbreak demonstrates that the combination of an *S. aureus* source (lesions) and time-temperature abuse led to sufficient growth of the organism to produce enough enterotoxin to cause a severe intoxication.

Following another graduation party in a private home in New York in 1986, 26 of 92 persons attending developed gastroenteritis, which was confirmed as originating from a norovirus strain in the fruit salad *(24).* An asymptomatic woman who had serum titer rises to norovirus had prepared the fruit salad; her son was ill and also was serum positive for the virus. It is likely that the ill child infected the mother and that the virus particles were introduced into the salad during its preparation. There were norovirus outbreaks in the community that preceded this event.

There were five outbreaks following picnic meals, with a total of 144 cases. Most were caused by norovirus or probable norovirus. One of these occurred in Minnesota in 2004, where a woman and her sister prepared the potato salad for a company picnic, and 33 persons developed laboratory-confirmed norovirus infection. The women denied any illness in either themselves or their families and claimed to have worn gloves during the salad preparation. However, they did not attend the picnic. Even though the servers were not ill either and used utensils to dispense the potato salad, the investigation concluded that the food workers who prepared the potato salad were the most likely source of the outbreak. A more serious outbreak occurred in 1990 in a similar scenario, with 24 persons ill with typhoid fever. Potato salad was prepared for a picnic by a recent immigrant from El Salvador who was asymptomatic. She did not attend the event but had *Salmonella* Typhi in her stool. She used her hands extensively in the preparation of the salad and did not practice good temperature control.

In 1999, 62 persons became ill with norovirus infection after a community event in a small Washington town where celery, green peppers, and green salad were served as appetizers *(94).* The appetizers were epidemiologically linked to the illness. Those who prepared the appetizers and other foods did not wear gloves, and at least one was symptomatic. Ice may also have been a vehicle. A woman changed diapers just prior to making chicken salad, and 15 people in the community experienced cryptosporidiosis *(14).* In another family event, the preparer probably contaminated the food with *Y. enterocolitica* by caring for a litter of sick puppies at the same time *(36).* An outbreak in Minnesota resulted from home-canned salmon being touched by a food worker who had previously diapered a grandchild positive for *Giardia (67).* At a family reunion in Utah, the HAV-infected salad maker thought her vomiting was related to her pregnancy; her transfer of HAV to the family members present resulted in 46 cases *(54).* Several home-linked *S. aureus* outbreaks were attributed to infected cuts or lesions on the hands. Food preparers in the home are not likely to wear gloves and are not as likely to wash their hands after handling raw meat or poultry as are employees in food service establishments *(60).* In other situations, the infected worker becomes the vehicle for the pathogen from the home to various food service settings. In 47 of the 816 outbreaks, family members infected food workers through direct contact. In 32 of these, a child with diarrhea or vomiting was specifically mentioned, and diapering a sick child was noted in five. Only four outbreaks were attributed to ill adults infecting the workers (wife or husband). Other

sources of infection were ill or excreting pets, infected visitors from Central America, and a plumber who was exposed to sewage and subsequently was in contact with a food worker.

We give two examples of church-related outbreaks. In New Mexico in 1989, 21 of 108 attending a church function developed giardiasis after eating lettuce, onions, and tomatoes *(72).* There was no obvious source of contamination, except for the preparer. In a larger outbreak in a small Swedish town in 1990, 169 people attended a birthday party at a church for one of the members and consumed sandwiches, rolls, and cake. Later, 122 developed fatigue, muscle weakness, and fever, followed by pharyngitis, between 15 and 70 or more hours after the event *(16).* The etiologic agent identified as *Streptococcus* group A caused severe illness in several attendees and resulted in one death. The sandwiches contained a variety of fillings and were prepared at the church by six members of the congregation. Food items either did not test positive or were not available for culture. Egg filling was the most likely vehicle, but it could not definitively be determined which of the seven food preparers was responsible, although the ''well-used'' apron of one of the women contained the same strain of the *Streptococcus.* Six of the food workers were culture positive, and five of these attended the party. The one who did not attend had transient respiratory symptoms that resembled a cold or an allergy, and she bit her fingernails frequently. However, the one who peeled and sliced the eggs had a sore throat but no fever a week before the party; her throat culture showed a heavy growth of the *Streptococcus,* and she was likely the index case. The eggs were stored in a refrigerator with a door that did not close effectively, and this could have resulted in temperatures suitable for the growth of the *Streptococcus.* The most important factor noted, however, was that covered sandwiches were kept at ambient temperatures for 5 h during a heat wave at >25°C, which would have certainly allowed the growth of the pathogen to levels that resulted in severe infections.

Closed communities, which are self-policing, may have outbreaks that do not receive outside attention unless they are large or serious enough. One event was reported in an Amish community in Minnesota in 2002 following a complaint from a bus group in which 15 of 40 members had gastrointestinal symptoms after a bus trip to southern Minnesota *(64).* The tour bus had made numerous stops, including at an Amish community. Four other tour groups, which had stopped at the community, also reported illness. Tours to the Amish community included stops at some private homes that sold jams, pastries, breads, and candy. These were unlicensed premises for selling food. In addition, seven people who purchased candies from a community farm and ate them at home became ill, for a total of 48 cases of norovirus infection. Eating homemade candy purchased from this farm was most associated with all the illnesses, and multiple members of this farm family had experienced gastrointestinal illness recently. Thus, the most likely source of the viral contamination of the candy was the ill farm family members who prepared and packaged the candy for sale. Some of the unlicensed community food vendors advertised on fliers distributed by the bus tour operators, and after letters of warning were sent out, the operators agreed to discontinue promoting unlicensed vendors on their tours.

Outdoor outbreaks, some with large case numbers, occurred on Native American reservations (121 cases of *Streptococcus* group A and 6 cases of *Salmonella* Typhi), at a music festival in Michigan in 1988 with volunteer food workers (3,175 *Shigella sonnei* cases), and at a mass gathering (Rainbow) in North Carolina (6,350 cases of *S. sonnei*). Moose soup prepared by a symptomatic food worker in a private home for an Alaskan community gathering resulted in 25 cases of shigellosis; the soup had been allowed to cool before being served *(28).*

Outbreaks involving retail food outlets. In the data, only 12 outbreaks (1.5%) and 267 cases (0.3%) were linked to retail food outlets. This relatively low incidence of outbreaks and cases may be because many of the foods sold in these outlets had avoided contamination with protective packaging, or the foods were purchased raw and cooked during preparation to destroy pathogens and prevent illness transmission. A few examples of outbreaks in retail outlets follow.

In the summer of 1988, 32 serologically confirmed HAV cases in one small Alaskan community were followed by an additional 23 secondary cases among household contacts of the original patients *(12).* A case-control study showed that the vehicle was an ice-slush beverage purchased from a local convenience market about a month earlier. No other food consumption or exposure category (including social events, restaurants, grocery stores, or international travel) was statistically associated with illness. The ice-slush beverage mixture was prepared daily with tap water from a bathroom sink with utensils stored beside a toilet. All five employees of the market denied having hepatitis symptoms; four of these were tested and were negative for IgM antibodies to HAV. The fifth employee, who was one of the two persons who prepared the ice-slush beverage, refused to be tested. However, a household contact of this employee had serologically confirmed HAV infection in early June and reported that the employee had been jaundiced concurrently with her illness.

A protracted typhoid outbreak that lasted 7 years occurred in Terrassa, Spain *(99).* A 76-year-old grandmother, an asymptomatic carrier of *Salmonella* Typhi, was the index case. She had previously run the delicatessen family business for many years, but even after retirement, she continued to help prepare the cannelloni once a week, handling ingredients after they were cooked. She had a history of chronic diarrhea with 3 to 10 painless watery stools every day. She denied she had typhoid fever, although four persons had become infected in her household 11, 12, and 30 years ago. She experienced upper abdominal pain, chills, and nausea a few months before the investigation, indicating a more pronounced infection. Twenty-four of the infected persons were regular customers who ate the cannelloni, along with three other persons, who were occasional

customers at the shop. This demonstrates a prolonged outbreak continued by intermittent exposure to low levels of *Salmonella* Typhi. The carrier had not been recorded as an employee and so had not been checked during the initial investigation of the outbreak, when a possible food source was suspected.

Outbreaks involving processing plants. Relatively few outbreaks where food workers were implicated have involved processing plants. This is because strict controls are usually in place, either voluntarily by management or by food control agencies that closely regulate the food because of the potentially widespread distribution of products. For large-scale food processors, most, if not all, of the food operations are automated, with little or no food contact taking place. However, smaller operations are vulnerable to contamination, especially if there is limited understanding of good manufacturing practices and the spread of disease.

Small bakeries have been responsible for very large outbreaks, because infected workers have mixed or applied icing by hand (Table 1). Sixty-one clinical cases of hepatitis that occurred in Michigan in April and May 1968 were traced back to the consumption of glazed and iced pastries at a bakery *(76).* One of the bakery employees had icteric illness 1 month before the outbreak. He was directly involved in handling and dipping cooked pastries into the glaze or icing. As a result of the investigation, the bakery minimized hand contact by requiring the use of pastry tubes for spreading the icing and tongs for dipping the pastries into the glaze. In another bakery outbreak with 78 cases of *Salmonella* Thompson, a full-time employee infected with *Salmonella* was responsible for removing freshly baked bread and buns from the cooling rack, feeding them through an automatic slicer, and then packaging the bread for distribution. She did not wear gloves and handled bread items with bare hands. She had one overnight hospitalization but continued working for a further 6 days until termination of employment. The bakery did not offer any formal training on safe food handling practices, and the procedures manuals were written in English, although many of the employees spoke only Spanish. One of the largest of the 816 outbreaks involved a worker preparing frosting in 2000. He had five episodes of diarrhea and two of vomiting during his 6-h shift when he frosted cakes, and 3,000 persons contracted norovirus infections after eating these cakes *(50).* His children, who were ill before he was, were the original source of the virus.

Fifty persons were infected with *Y. enterocolitica* after eating contaminated tofu (soybean curd) in Washington State between December 1981 and February 1982 *(80).* The majority had gastroenteritis; two had appendectomies, and one had a partial colectomy. *Y. enterocolitica* serotype O:8 was isolated from the patients and the tofu. Two of 13 workers were culture positive for the *Yersinia,* although they denied illness. The plant had no hand washing facilities; only pit privies were available and a badly contaminated, untreated surface water source (so-called spring water) that was positive for the *Yersinia.* The workers packed the tofu in this water with their bare hands prior to shipment.

In 2000, a nationwide shigellosis outbreak occurred in 406 persons; the infections of these individuals were traced to the consumption of a commercially prepared dip *(50).* The dip was a refrigerated product consisting of five layers: beans, salsa, guacamole, nacho cheese, and sour cream. The cheese layer was prepared in large batches by the same employee once or twice a week. Blocks of cheese were cut into chunks with a knife, broken into pieces by hand, and placed into a colloid mill, which sheared the mixture into a paste. All employees working on the dip production line were questioned about gastrointestinal illness just before and during the suspected production period of the contaminated dip. Only one employee reported having gastroenteritis during that period. He went home ill with diarrhea on 3 January and returned to work on 5 January (the plant was not in operation on 4 January). His diarrhea reportedly lasted 1 day. Stool cultures were not taken at the time of his illness. He was an hourly employee and had no paid sick leave. Breaking up the cheese by hand and feeding it through the colloid mill was his sole responsibility.

Outbreaks involving commercial travel. Commercial travel has only infrequently been associated with foodborne illness. We illustrate this by listing 12 outbreaks on commercial airline flights, 3 on cruise ships, and 3 on commercial trains (Table 7). All the foods implicated in outbreaks associated with the ships, planes, and trains were RTE (ice, fresh-cut fruit salad, omelets, parsley sprinkled on potato salad, and cold dishes with aspic). Six of the airline outbreaks involved illnesses on multiple flights, because contaminated foods were prepared at a central commissary and loaded onto many different planes traveling to multiple destinations, often to many different countries. However, as pointed out in some of the investigations, attention is drawn only to public health authorities when a few individuals express their concern. We focus on only a limited number of cruise ship episodes because it is unusual that food workers are specifically implicated, even though many cruise ship episodes are publicized in the media, especially norovirus outbreaks. Frequently, large groups arrive on charter flights and are confined to the ship, and several passengers may be asymptomatic carriers of a pathogen, although it has been noted that some on board the ships may already be ill *(97).* Frequently, many food items are served buffet style during extended periods, which facilitates the spread of highly infectious agents like norovirus. There are far fewer meals served on trains and, therefore, few episodes are reported. However, because of the short duration of many train rides, infected passengers would be dispersed, and subsequent illness would not be easily traced to food eaten on the trains, even if this were the case. With the dinner train episodes described below, all the passengers aboard ate, and the follow-up investigations were much easier.

Airplanes. The number of illnesses associated with aircraft is very low relative to the thousands of daily flights around the world. However, illnesses on domestic flights

TABLE 7. *Outbreaks associated with food workers occurring in trains, cruise ships, and planes*

Conveyance	Narratives	Reference(s)
Airplane (England to Australia, 1970)	Forty-seven cases of *Vibrio cholerae* and one death were associated with a flight from London to Sydney with a stopover in Bahrain. Eggs were identified as the food vehicle	*78*
Airplane (Canary Islands to Sweden, 1971)	A total of 219 passengers on several flights were ill with shigellosis from meals prepared by the same caterer	*39*
Airplane (Portugal to three U.S. cities, 1973)	A total of 247 cases of *Staphylococcus aureus* infection were associated with consumption of a custard dessert on three separate flights. The pathogen was isolated from hands and nasal cavities of the catering staff	*6, 81*
Airplane (Japan to Denmark, 1975)	A total of 197 infected persons (144 hospitalized) with *S. aureus* were associated with consumption of omelets with ham slices. The cook handled cooked ham with an inflamed lesion on his finger. The ham was left at ambient temperatures for 6 h before refrigeration	*7*
Airplane (to and from the Canary Islands to Finland and Germany, 1976)	About 1,800 cases occurred on several charter flights in February 1976. Egg-mayonnaise salad was the likely source. *Salmonella* Typhimurium phage 96 was isolated from passengers, mayonnaise, and one food worker in the Las Palmas catering establishment. There were three deaths	*39*
Airplane (France to many countries, 1976)	Forty-five outbreaks of *Salmonella* Brandenberg infection were associated with consumption of many cold dishes, with both passengers and aircrew affected. One catering staff member was infected and involved in preparing the implicated foods	*98*
Airplane (Lisbon to Boston, 1982)	Two outbreaks of *S. aureus* intoxication were associated with consumption of custard—one with crew (10 cases) and the other with passengers (6 cases), both having the same source of catered food	*81*
Airplane (Rio de Janeiro to the United States, 1982)	Twenty-eight passengers were ill from ingesting staphylococcal enterotoxin in éclairs served on one flight	*6*
Airplane (United Kingdom to the United States and other countries, 1984)	A total of 631 passengers, 135 aircrew, and 100 caterers and loaders were infected with *Salmonella* Enteritidis following consumption of food glazed with aspic (two passenger deaths). The ill chef prepared aspic glaze that was held at ambient kitchen temperatures for up to 3 days and was used to glaze departing airline foods	*5*
Airplane (Finland to Rhodes, 1986)	This airplane outbreak of 91 cases of *Salmonella* Infantis occurred a week after the train outbreak, but the same catering group was involved. Ill food workers were allowed to continue preparing food for flights, although one flight was already affected. No specific food was identified as the vehicle	*38*
Airplane (Ontario, Canada, 1988)	Twenty cases of *Salmonella* Enteritidis phage type 8 were isolated from passengers, crew members, and a food worker. The food vehicle was not identified	*89*
Airplane (United States to Germany, Japan, Mexico, and the United Kingdom, 1988)	A total of 725 cases of shigellosis occurred on multiple flights from Minneapolis for the United States and overseas. Two implicated food workers had extensive hand contact with fresh fruits and vegetables, and hand washing was not effectively carried out at the catering establishment	*40*
Cruise ship (Florida, 1989)	A total of 19 passengers and 2 crew members infected with *Shigella flexneri*. Thirteen people were hospitalized. A case-control study implicated German potato salad (typically made with potatoes, bacon, and green onions and served warm) as the vehicle of transmission. It was prepared and probably infected by a food worker from a country where multiple-antibiotic-resistant *Shigella* is common. Limited availability of toilet facilities for the galley crew	*58*
Cruise ship (Hawaii, 1990)	A total of 217 cases of norovirus infection associated with consumption of fresh-cut fruit served at two buffets. Although the cooks who prepared the fruit reported being well, crew members may be reluctant to report illness because of concern about job security. Other cooks (including the roommate of one of these reportedly well cooks), galley workers, and waiters were also sick	*42*
Cruise ship (Hawaii, 1992)	A total of 202 cases of norovirus were associated with the second outbreak on this cruise ship within a few days. Ice machine was a likely vehicle, with ice contaminated by a server's hands while scooping or an undetermined source linked to the previous outbreak not removed when the ship was cleaned between cruises	*48*
Train (Finland, 1986)	Infected persons had eaten egg sandwiches on sale in buffet cars, prepared by a catering firm where a number of food workers reported illness. A total of 600 persons were exposed over 3 days, resulting in 107 cases of *Salmonella* Infantis. The spread of the outbreak was exacerbated by a heat wave at the time and poor cold storage facilities	*38*
Train (Washington, United States, 1992)	Fifty-six cases of norovirus were associated with consumption of pear dessert on a ''dinner train.'' Bottled water was used to wet hands for hand washing because there was no running water on the train	*92*
Train (Washington, United States, 1996)	Two cases of norovirus were associated with consumption of green salad on a ''dinner train.'' Two food workers were ill, one before and one after exposure	*93*

get little more than a press write-up and are rarely recorded in the scientific literature. For instance, during a Canadian flight in 1988, 20 salmonellosis outbreaks occurred among the passengers, the crew members, and the food worker who prepared the food, although no specific food vehicle could be identified *(89).* However, outbreaks involving international flights may be highly publicized, and some were well investigated (Table 6). During a flight from London to Sydney in 1970, a stopover for fuel and food in Bahrain introduced eggs contaminated with *V. cholerae* by asymptomatic carriers involved with catering *(78).* The first person to have cholera was hospitalized in Sydney, and authorities were concerned that there were more infected persons, although none was apparently ill on other flights. Tracing persons who could transmit *V. cholerae* was complicated because there was a stopover in Kuala Lumpur and Singapore, and some passengers flew on to New Zealand. Fecal samples were eventually collected from all 373 passengers and crew members; 47 were positive, although only 25 became symptomatic. A 65-year-old passenger died. Hors d'oeuvres, which included stuffed eggs and duck prepared in Bahrain, were the most likely vehicles for the pathogen, and it is probable that some meals were not refrigerated for approximately 5 h. Two food workers were positive for the same organism 14 days after the outbreak, and one had chopped and minced the meat and poultry used in the aircraft meals. Both denied they were ill, although it is likely they were infected from a cholera outbreak that had begun in Bahrain 2 weeks before this outbreak.

A flight attendant and 196 passengers developed rapid onset of vomiting and diarrhea following the ingestion of ham and cheese omelets served during a chartered flight for a tour group from Tokyo to Paris that stopped en route in Alaska and Denmark *(7, 21).* Breakfast meals prepared in Anchorage boarded at the Alaskan stop. A cook with an infected finger prepared some of the omelets and ham. The ham was left at ambient temperatures for 6 h before being placed in a 10°C cooler overnight (14.5 h). The cook probably handled 217 of the ham slices either directly during preparation or by placing his hands repeatedly into the plastic bucket that contained the slices prepared by others. *S. aureus* was isolated from the food samples.

Aspic glaze on many food items, including pork, salmon, prawns, and crayfish, served on 3,103 British Airways flights, with a total of 220,553 passengers from London to Saudi Arabia, South Africa, Canada, and the United States in March 1984, resulted in 631 first- and club-class passengers, as well as 135 crew members, developing salmonellosis *(5).* Tauxe et al. *(81)* noted that on one of these flights to Los Angeles, there was an 81% attack rate, but only 7% reported illnesses; therefore, the number of cases in all the affected flights may have been much higher than was estimated. Two chefs had symptomatic salmonellosis in March when the outbreaks occurred, and one continued working, preparing the cold dishes with aspic. In the catering establishment, during glazing, the products were suspended on wire racks while the gelatin glaze was poured over them. The aspic was not always prepared fresh according to management instructions; rather, in some cases, it was used after remaining at ambient temperatures for up to 3 days, allowing *Salmonella* transferred from the infected food worker to the aspic to grow rapidly. One hundred catering and loading staff members were also infected, although most were asymptomatic, indicating they had close contact with the infected chefs or more likely sampled food items or pilfered whole first-class meals, as was determined during the investigation.

Hatakka *(39)* wrote a comprehensive review of outbreaks on commercial flights and appropriate standards in Finland. The legal requirement in Finland demands that a food worker who travels outside Nordic countries be tested for *Salmonella,* and flight kitchen food workers are screened for *Salmonella* once a year. Many airlines in other countries also demand *Salmonella* testing if flight kitchen employees travel abroad, although there is no legal requirement for this. Illnesses acquired during air flights are less common today because of better cold chain control by caterers and aircraft crew members. Stopovers are unnecessary for refueling and revictualization, lessening the risk of an added food service link. In addition, fewer meals are now served on domestic flights during times of economic austerity for airlines.

Cruise ships. Large outbreaks among passengers and crew members of cruise ships have been described in recent years, perhaps because of increased popularity of cruises, required reporting of illnesses, more media attention to outbreaks, and better diagnostic tests, especially for norovirus *(1, 11, 15, 18, 34, 46, 70, 71).* However, if outbreaks do occur, the source of infection is difficult to determine because of the rapid spread throughout the ships. Also, the contaminated parts of the ships are difficult to sanitize to prevent reinfection on succeeding cruises. Norovirus outbreaks have twice occurred on two consecutive cruises around the Hawaiian Islands, once in 1990 and again in 1992 (Table 6). In the 1990 scenario, only the second episode was investigated. Within 48 h of the second cruise casting off, and before the ship had made its first port of call, most of the illnesses had occurred *(42).* Fresh-cut fruit was the vehicle associated with 217 of the infected persons (41% of the passenger manifest). Although the two cooks who prepared the fruit claimed to be well, one of them became ill on the second day of the cruise and was probably asymptomatic at the time of preparation. The second large cruise outbreak occurred in 1992, where the use of bare hands to scoop ice was a major factor in the spread of norovirus among 672 passengers and crew members *(48).* There had been an outbreak on the last 2 days of the previous cruise, and many passengers and crew members became ill within 24 h of the second cruise. Although the ship was sanitized and the food was discarded after the ship docked from the first cruise, the five ice machines had not been cleaned, nor had the ice been discarded. As has already been mentioned, it is difficult to establish the precise role of the food worker in the origin of norovirus infections aboard ships. However, the continuation of outbreaks on consecutive cruises with new passengers and the resurgence of outbreaks caused by the same virus strains as on previous

cruises on the same ship, or even on different ships of the same company, suggest that environmental contamination and infected crew members can serve as reservoirs of infection for passengers *(15).*

Trains. Improperly stored egg sandwiches led to over 100 illnesses among 600 patrons on seven Finnish routes initiating from Helsinki in early August 1986 *(38). Salmonella* Infantis was isolated from passengers and 17 employees at the catering establishment, which was closed for 10 days while the premises were cleaned and disinfected. The infected employees handled cold and hot foods, bakery products, and packaging; many of them were asymptomatic at the time of the inspection. *Salmonella* was found in only two hot meal samples. There was a risk of cross-contamination at the plant because the transport routes for the raw and cooked foods were not separated. Three workers experienced diarrhea on 1 August but were not asked to go home, and they were not given any instructions on how to improve their hygiene or handling of foods. Subsequently, several other workers suffered from gastrointestinal symptoms. The sandwiches prepared on 31 July, 1 August, and 2 August were kept at 4°C and then transported to the trains 20 km away in unrefrigerated vehicles under unseasonably warm conditions. The report indicated that probably an asymptomatic carrier prepared the breakfast for other employees by slicing cold cuts and bread, which were left at a warm room temperature for 2 h before they were eaten. As a result of the outbreak, the catering establishment suffered adverse publicity and financial loss.

Symptomatic workers caused norovirus infections (confirmed by the Kaplan criteria) on two Washington ''dinner trains,'' where four- to five-course gourmet meals were served during short train rides *(92, 93).* In the 1992 outbreak, 56 of 67 passengers were infected following meals on a dinner train in eastern Washington. Two cooks (husband and wife) had ill children at home (with diarrhea) 2 days before food preparation. One cook became ill on the day the meals were prepared and served, and the other became ill 24 h later. There was no running water, and the cook used bottled water to wet hands as a substitute for hand washing. The two foods implicated were pear desserts and ice, which were prepared with bare hands. In 1996, a smaller episode occurred on another dinner train, this time in western Washington. Green salad was the only RTE food eaten by both ill passengers. The two workers preparing the salad and other foods were also ill with gastrointestinal symptoms. One was ill before the meals were prepared (the most likely source of the infection), and the other was ill after the train excursion was over. In summary, it seems that in recent years, illnesses on airlines are occurring less often, train-associated outbreaks are relatively rare, but those on cruise ships are occurring more frequently than two or more decades ago.

This article examines in depth the burden of foodborne disease in outbreaks where food workers have been implicated in the spread of the pathogenic agent. Although the overall hospitalization rate (3.5%) and fatality rate (0.12%) were low in these reports, the economic and social costs were considerable. There were some very large outbreaks; eleven had over 1,000 cases, while four had over 3,000 cases. Large outbreaks frequently occurred because of the continual exposure of large groups to a pathogen, either because the source had not been identified soon enough or because control measures had been insufficient to eliminate the agent, such as at refugee camps or large outdoor events. However, in several other large outbreaks, the amount of contaminated food was so great that thousands of persons were exposed by the same batch of food; this occurred with frosting on cakes, imported raspberries, and items served at large receptions or commissaries. The agents in large outbreaks also tended to be highly infectious, such as *Shigella* or norovirus. Because RTE foods are not further processed or cooked, subsequent contamination by infected food workers frequently led to outbreaks. These included produce and baked goods as well as beverages that would not normally allow the growth of pathogens. However, many of these were of viral origin with sufficient particles to cause an infection without further multiplication. Food service outlets, such as restaurants, catering companies, and schools that served large numbers of patrons, were the most frequent settings implicated. However, episodes linked to bakeries, hospitals, camps, homes, and church meals highlight the necessity for those who prepare and serve meals in these operations to excuse themselves from food preparation if they are ill or exposed to infected individuals.

Commercial travel, primarily by ship, air, or train, has been associated with several outbreaks; because the patrons have limited choices and are confined within their means of transportation, the impact of illness is often quite dramatic and newsworthy. However, the role of the infected food worker in outbreaks on cruise ships is difficult to determine because the passengers may be as much a source of infectious agents, such as norovirus, as the crew members. All these data indicate that not only are outbreaks involving infected food workers widespread, but they can also cause serious illness and death. It is vital to implement strategies that reduce the likelihood of their occurrence. However, as previously noted, it is not easy to attribute blame to infected food workers in an outbreak situation because of the multiple contributing factors identified during investigations. There is, unfortunately, always uncertainty surrounding the role of the food worker's contribution to outbreaks. The third article in this series will categorize the outbreaks more specifically to identify different relevant control measures.

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